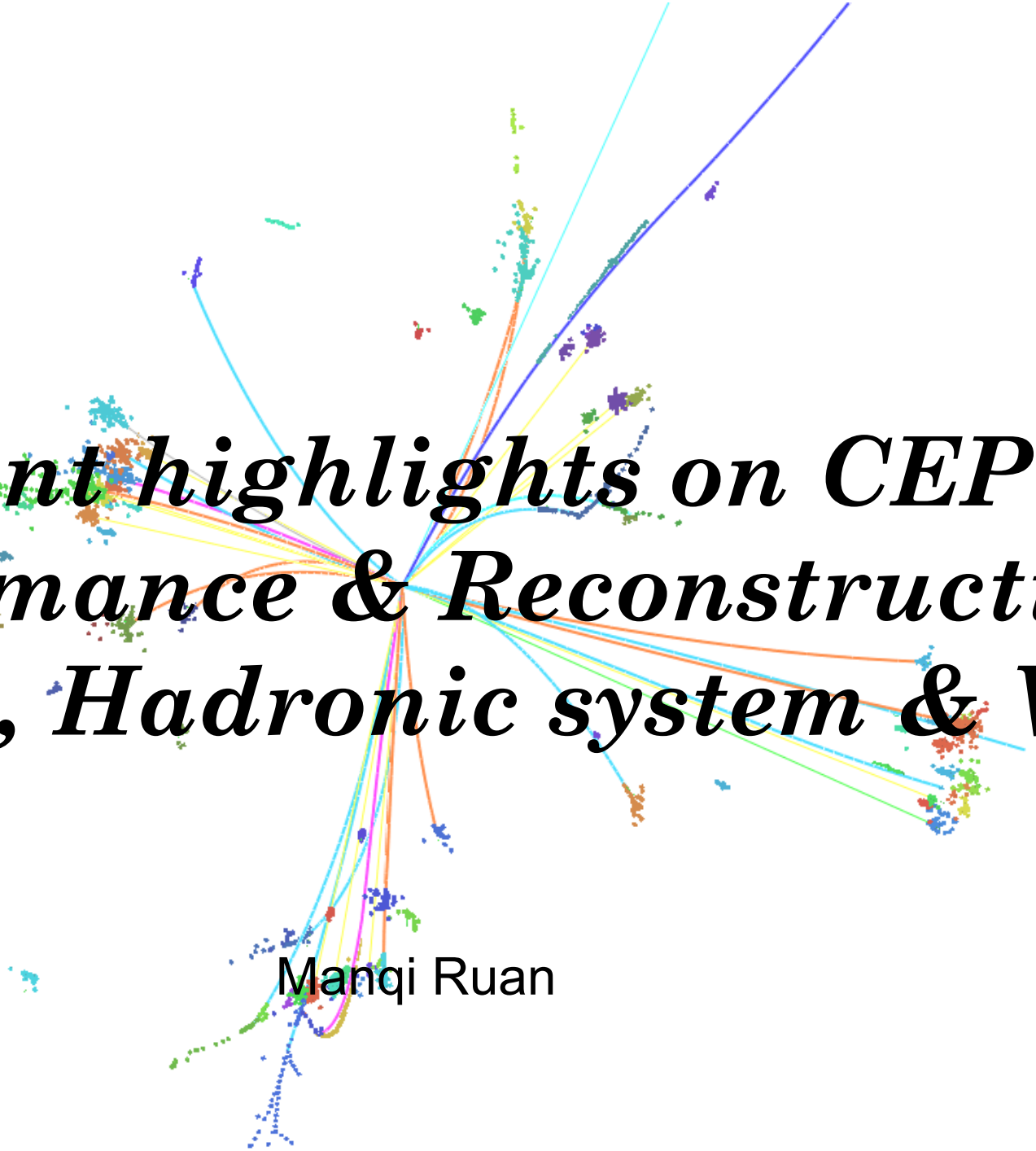
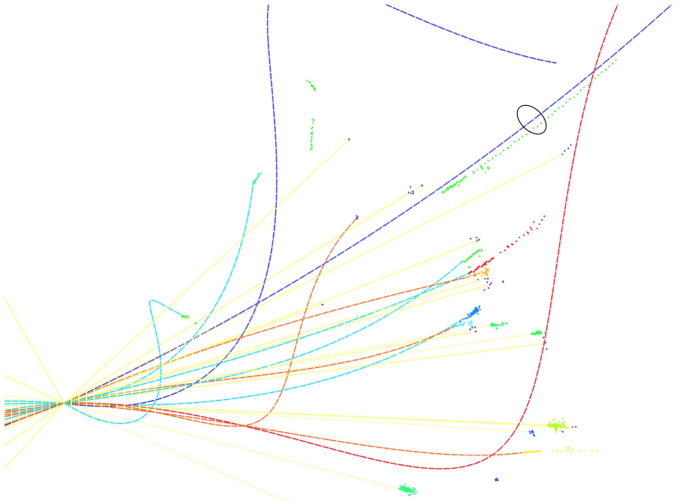


Recent highlights on CEPC Performance & Reconstruction: Lepton, Hadronic system & VTX

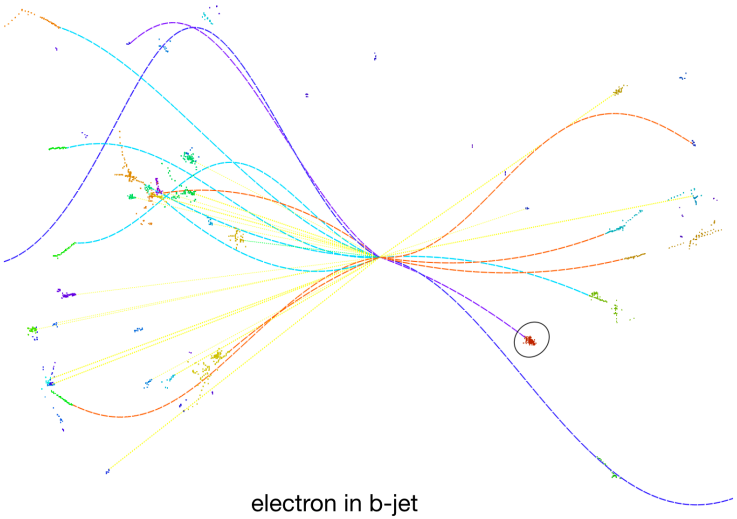
Manqi Ruan

Lepton

- Electron & Muon
  - Isolated
  - Inside jet
- Tau
  - Tau only event ($Z \rightarrow \tau\tau$; $\nu\nu H$, $H \rightarrow \tau\tau$)
  - Isolated
  - Inside jet
- Main contributor: Dan



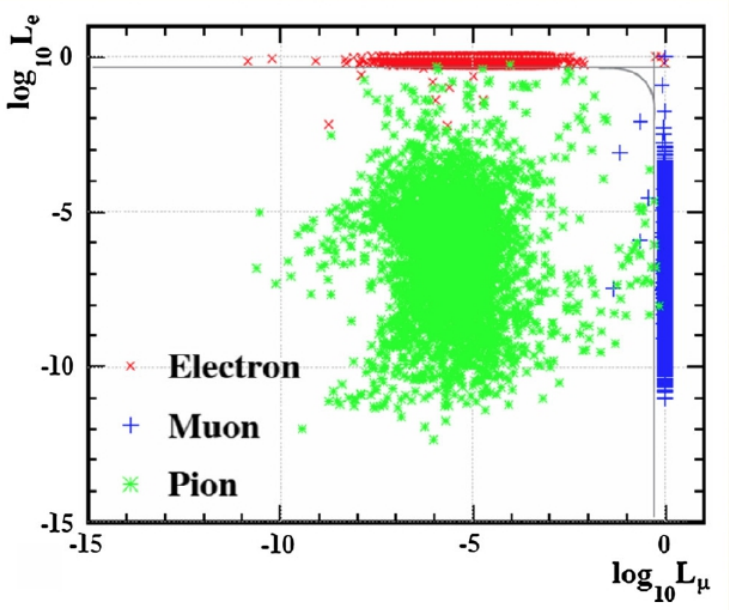
muon in b-jet

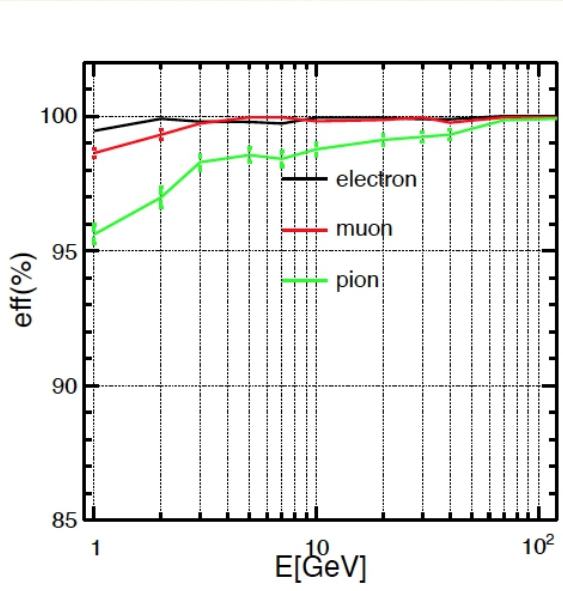


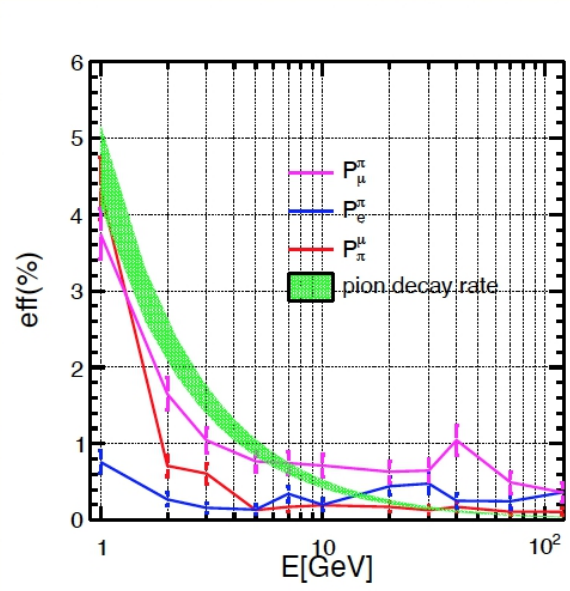
electron in b-jet

Light Lepton Identification

- LICH uses TMVA methods to summarize 24 input variables into two likelihoods, corresponding to electrons and muons.
- The efficiency for electron and muon is higher than 99.5% (E>2 GeV). Pion efficiency ~ 98%.







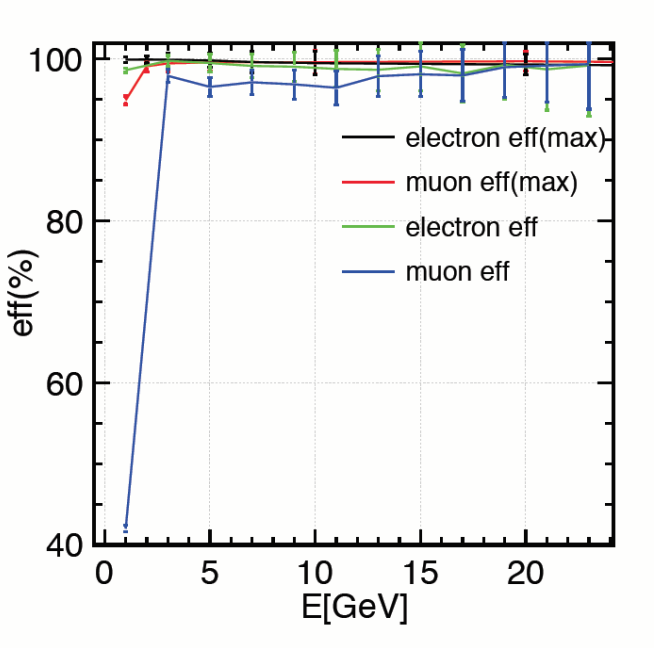
Migration Matrix at 40GeV (LICH)

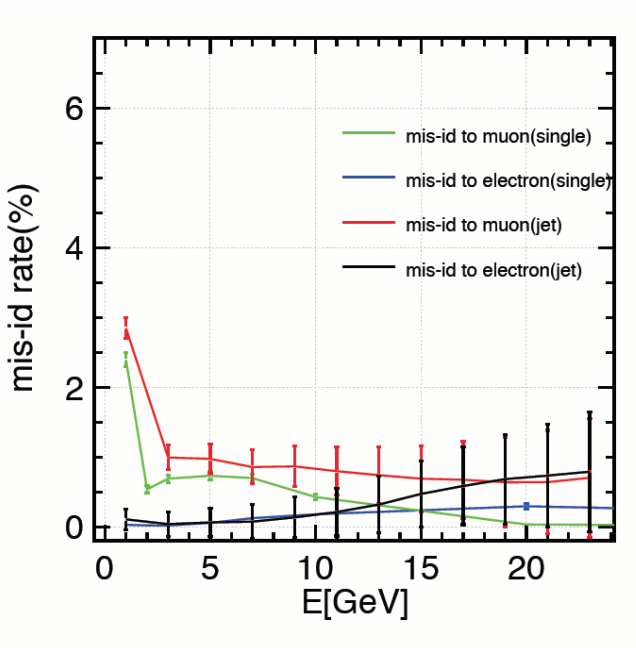
Type	e^- *like*	μ^- *like*	π^+ *like*
e^-	99.71 ± 0.08	< 0.07	0.21 ± 0.07
μ^-	< 0.07	99.87 ± 0.08	0.05 ± 0.05
π^+	0.14 ± 0.05	0.35 ± 0.08	99.26 ± 0.12

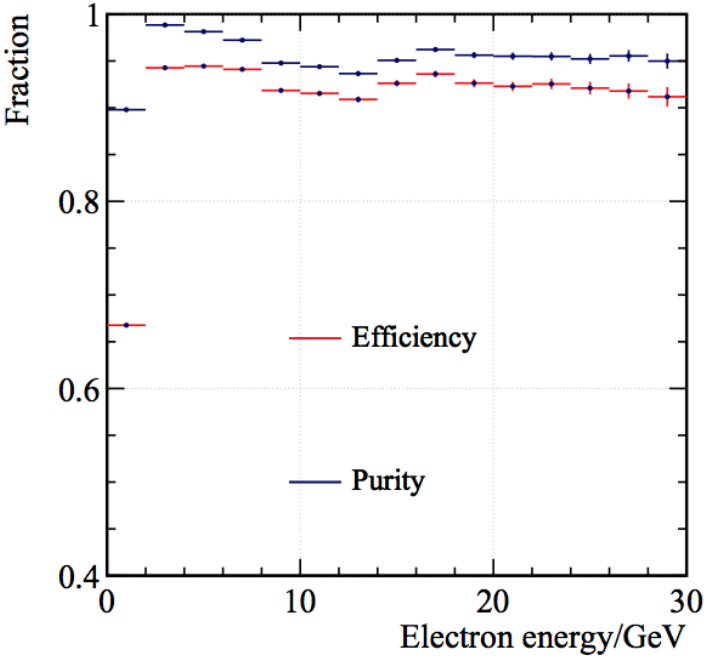
Migration Matrix for ALEPH PID ($> 2\,GeV$)(*Eur.Phys.J.C20:401-430,2001*)

Type	e^- *like*	μ^- *like*	π^+ *like*	undefined
e^-	99.57 ± 0.07	< 0.01	0.32 ± 0.0	0.09 ± 0.04
μ^-	< 0.01	99.11 ± 0.08	0.88 ± 0.08	0.01 ± 0.01
π^+	0.71 ± 0.04	0.72 ± 0.04	98.45 ± 0.06	0.12 ± 0.03

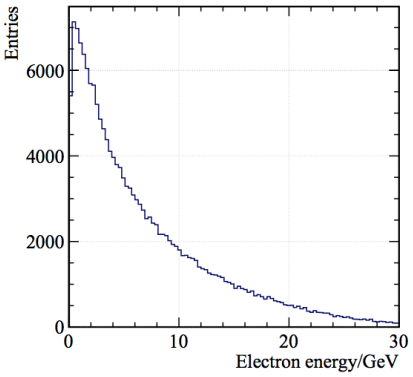
Leptons in jet (endcap): slightly degrading





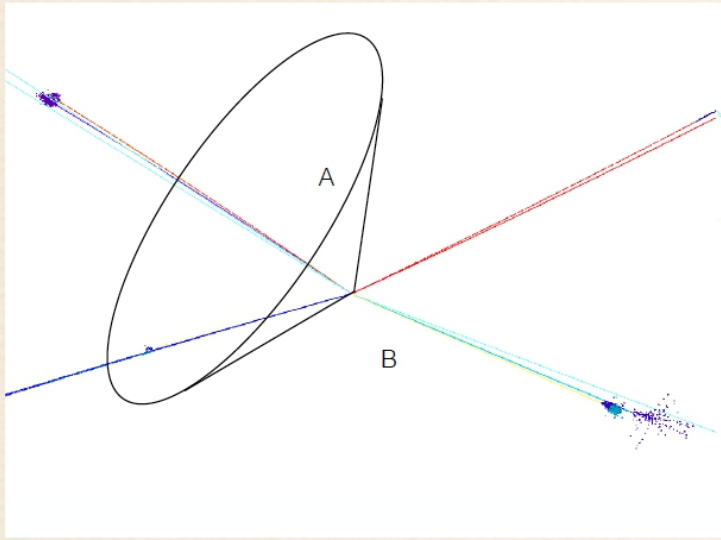


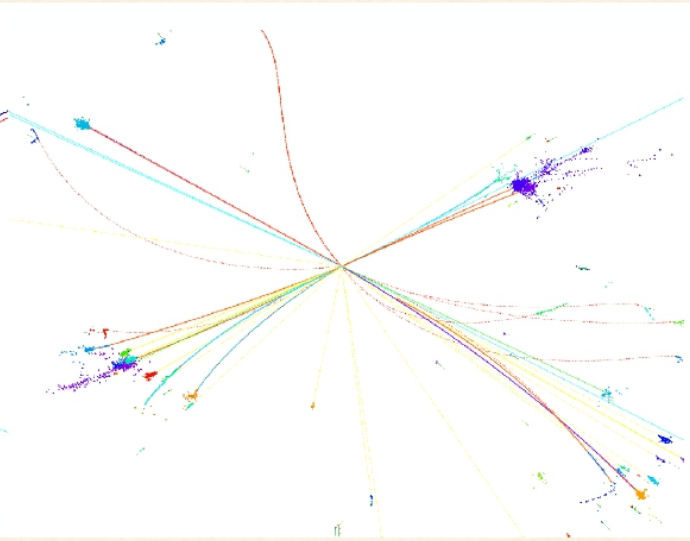
- Induced by the limited performance on PFA Clustering.
- Right plot: eff & purity of electron finding in Bc→Tv analysis
  - An ideal lepton id can improve ~ 10%, visible, **not significant.**

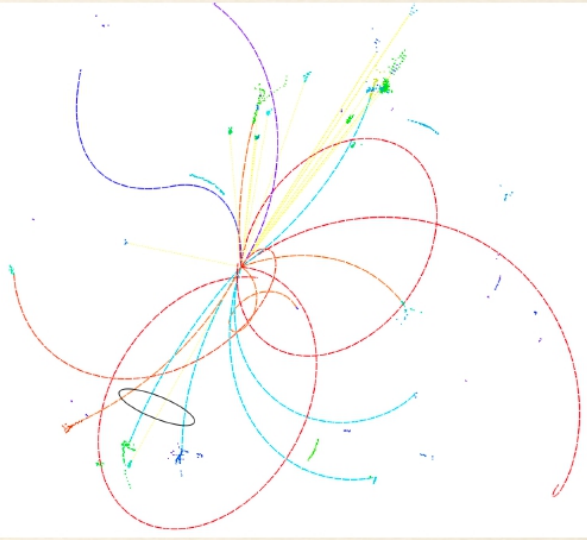


Event topology

- llH channel / $Z \rightarrow \tau\tau$
- qqH (isolate τ with jets)
- τ inside jets





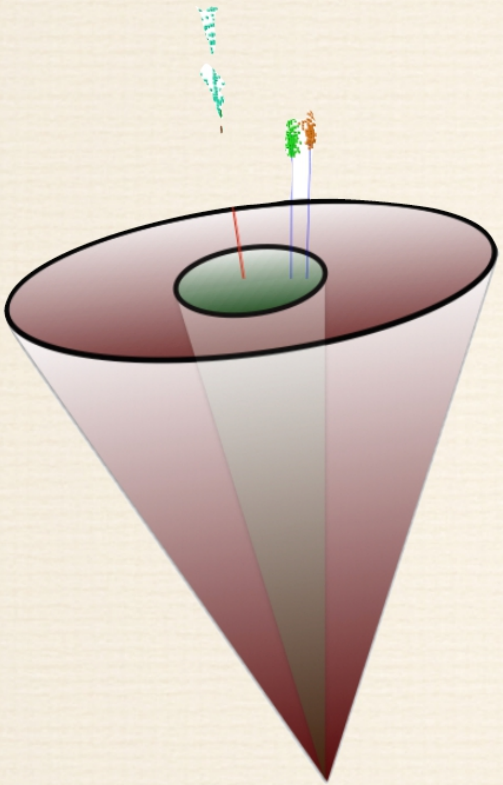


- (Veto the two isolate lepton)
- Divide the whole space into 2 part
- Multiplicity & Impact parameter

- Tau jet reconstruction package: TAURUS

- TAURUS with different parameters

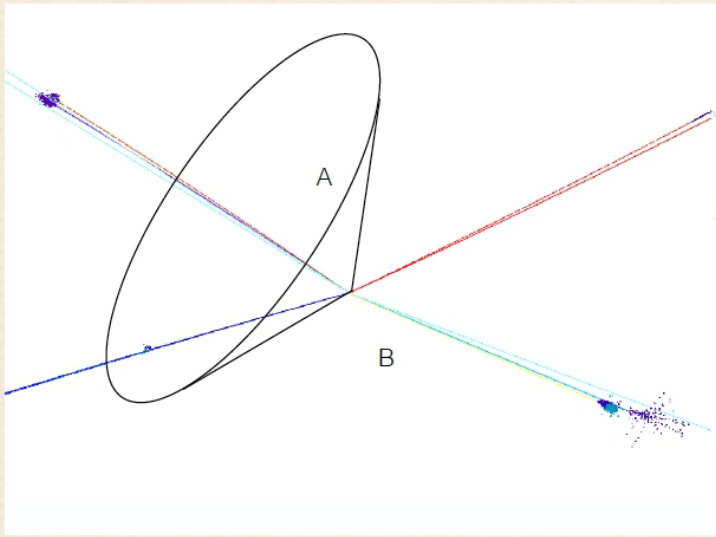
Taurus

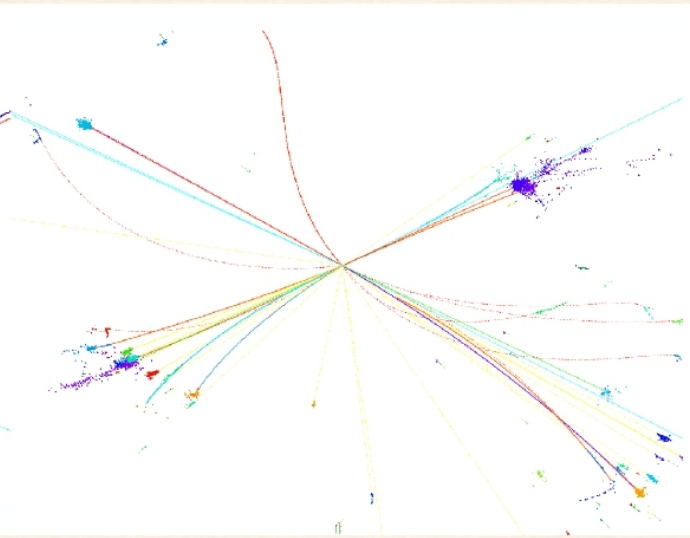


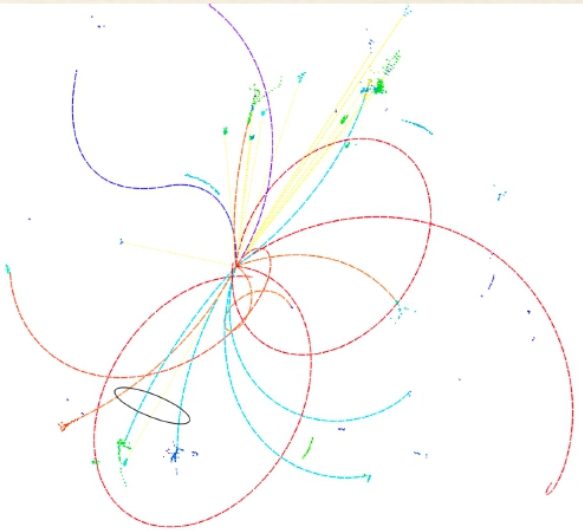
- Double cone based algorithm
  - Find seeds(Tracks with enough energy)
  - Collect particle in two cones
  - Use the multiplicity, energy ratio between two cones, invariant mass for τ tagging

Event topology

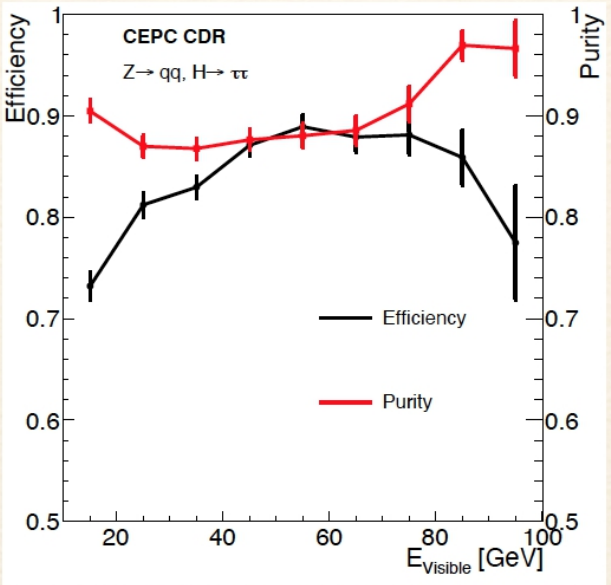
- llH channel / Z→ττ
- qqH (isolate τ with jets)
- τ inside jets

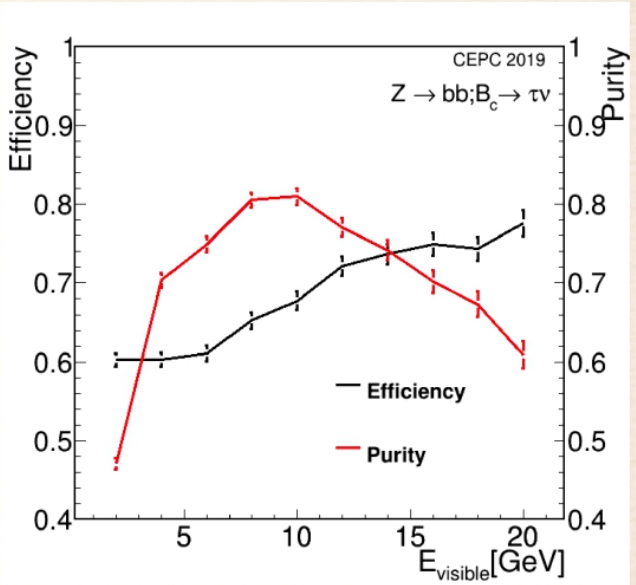






- (Veto the two isolate lepton)
- Divide the whole space into 2 part
- Multiplicity & Impact parameter
- Efficiency > 90%





Hadronic System

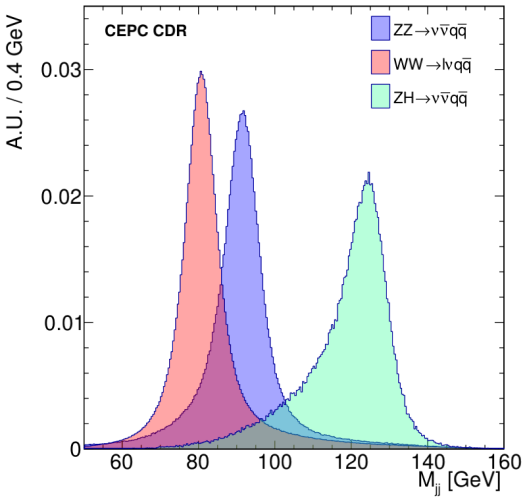
- Identification of the hadronic system, and measurement of its 4-momentum
  - Identification: well, leptons can be very well identified
  - Tagging of ISR photon, Bremstrahlung/FSR from lepton, etc, Converted Photon (EM objects) still needs some development (Not urgent, we know it works)
  - 4-momentum measurement: quantified using BMR

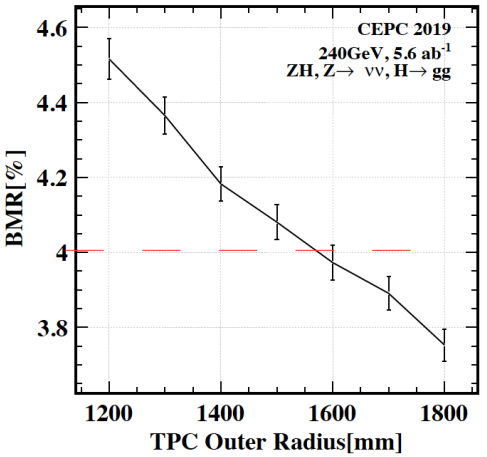
- Identification of Color Singlet in Multi-jet events, i.e., identify single Boson in full hadronic events of ZZ, ZH, WW, etc.
  - Challenge, important & Very interesting

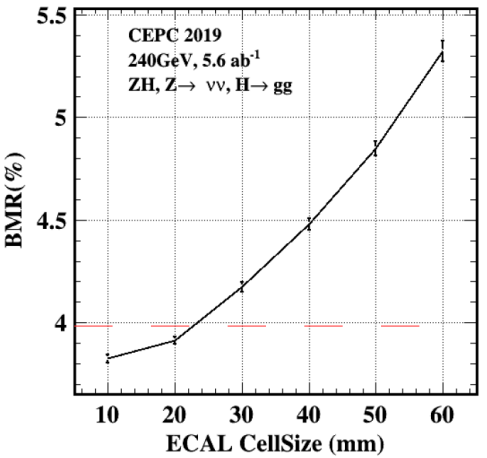
- Differential measurements
  - Current criteria: Jet Clustering and Matching
  - Going beyond?

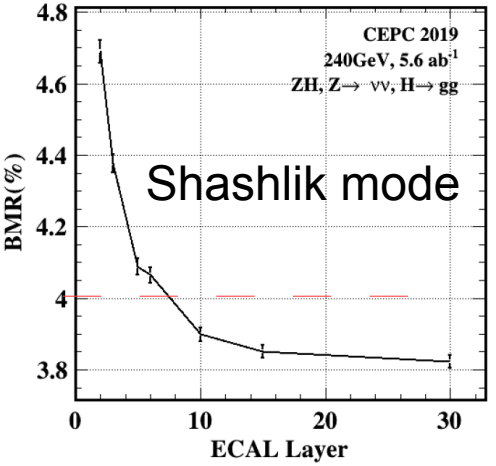
BMR oriented Optimization

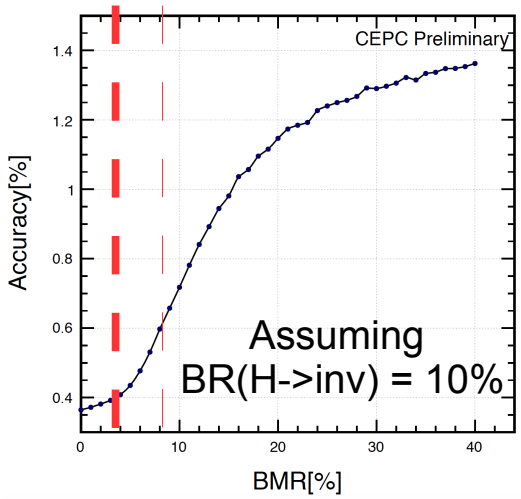
Yukun, Dan, Jiechen, Hanhua, etc

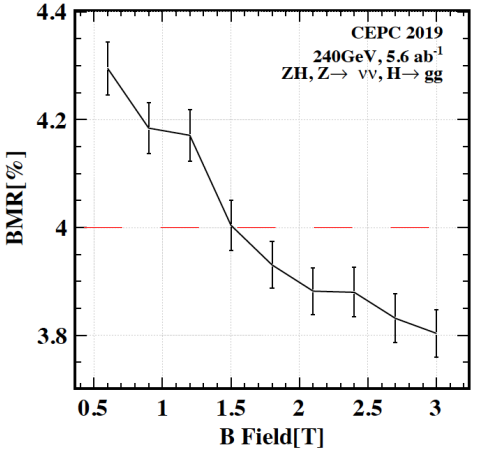


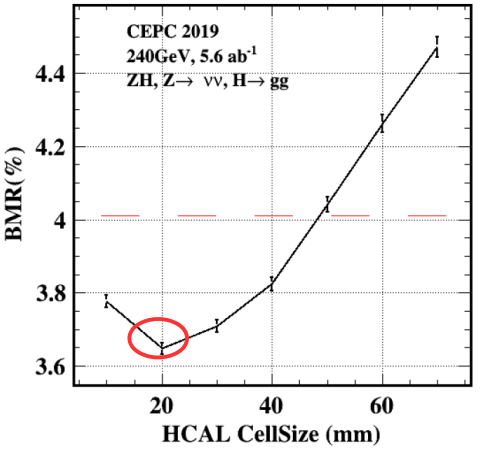


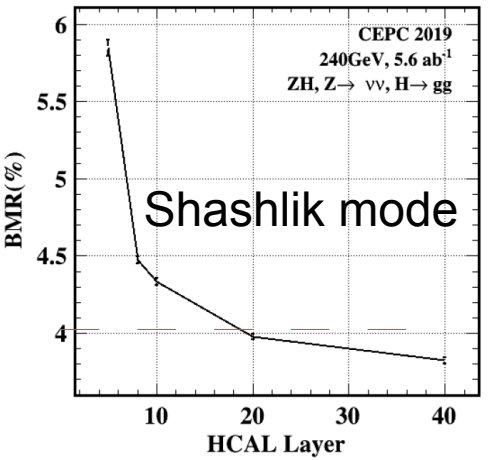












CEPC requirements: BMR < 4% (3.8% achieved at CDR baseline)

Dependence between BMR & Detector Geometry quantified

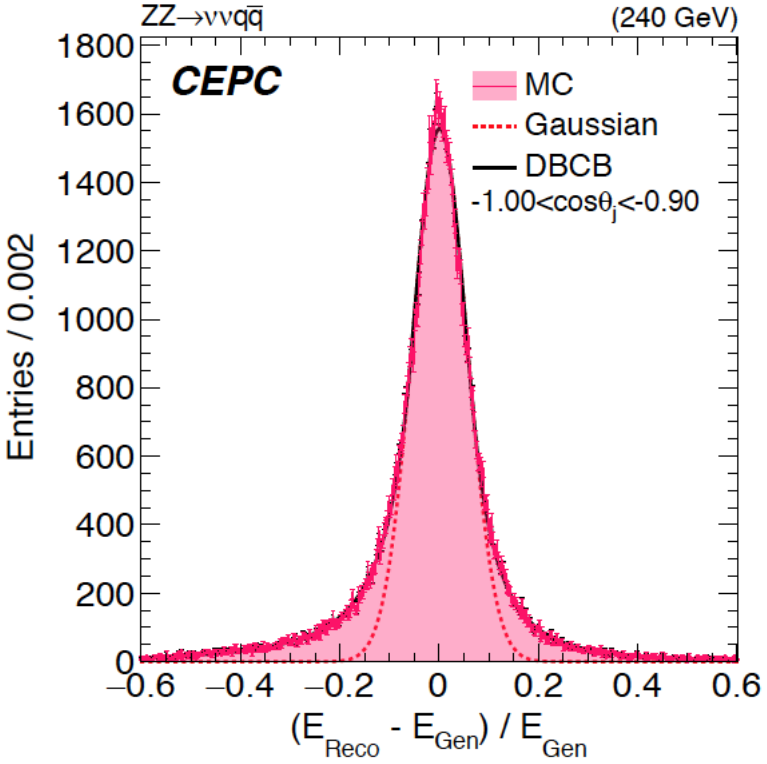
BMR & Optimization

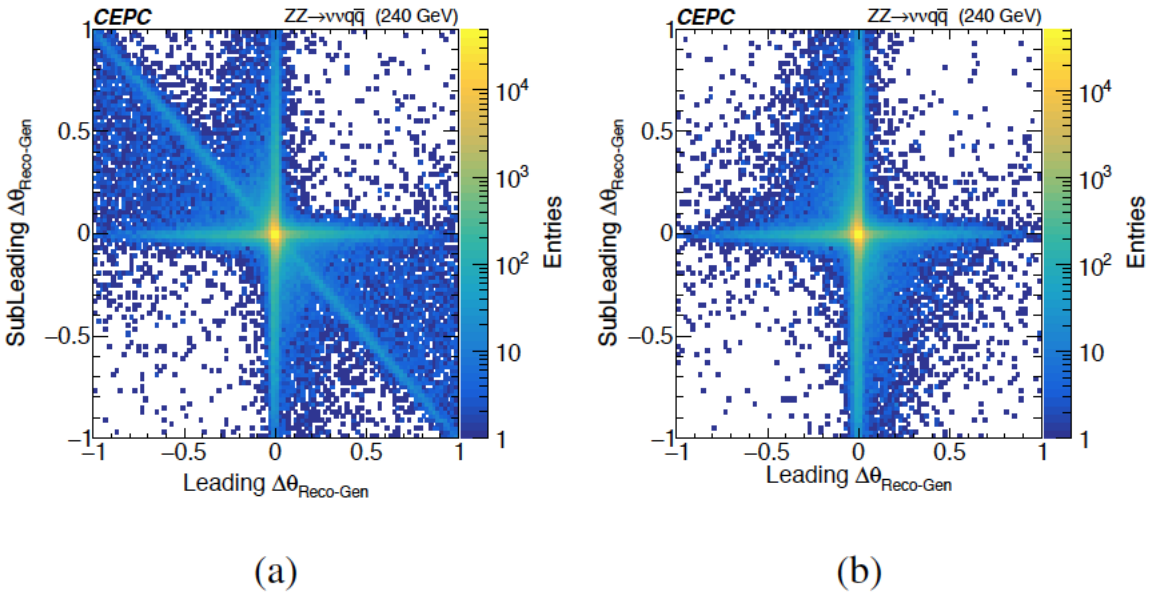
- BMR = 3.8%, 3.6% seems reachable without fundamental algorithm change...

- Allowance of 4%, BMR = 3.6/3.8% means we can
  - HCAL optimal size ~ 2 cm -> reduce the HCAL # Channel to a quarter
  - Reduce the tracker R&Z by 24/12%
  - Reduce the ECAL #Channels to a quarter: either by double Cell size, or reduce the #Layer
  - Reduce the B-Field by 50%
  - Increase the HCAL Cell size ~ 5 cm! HCAL #Cell reduced to 4%...
  - Reduce the HCAL #Layer by 50%

- Further improving of BMR... by algorithms... is critical.

Differential Jet Response

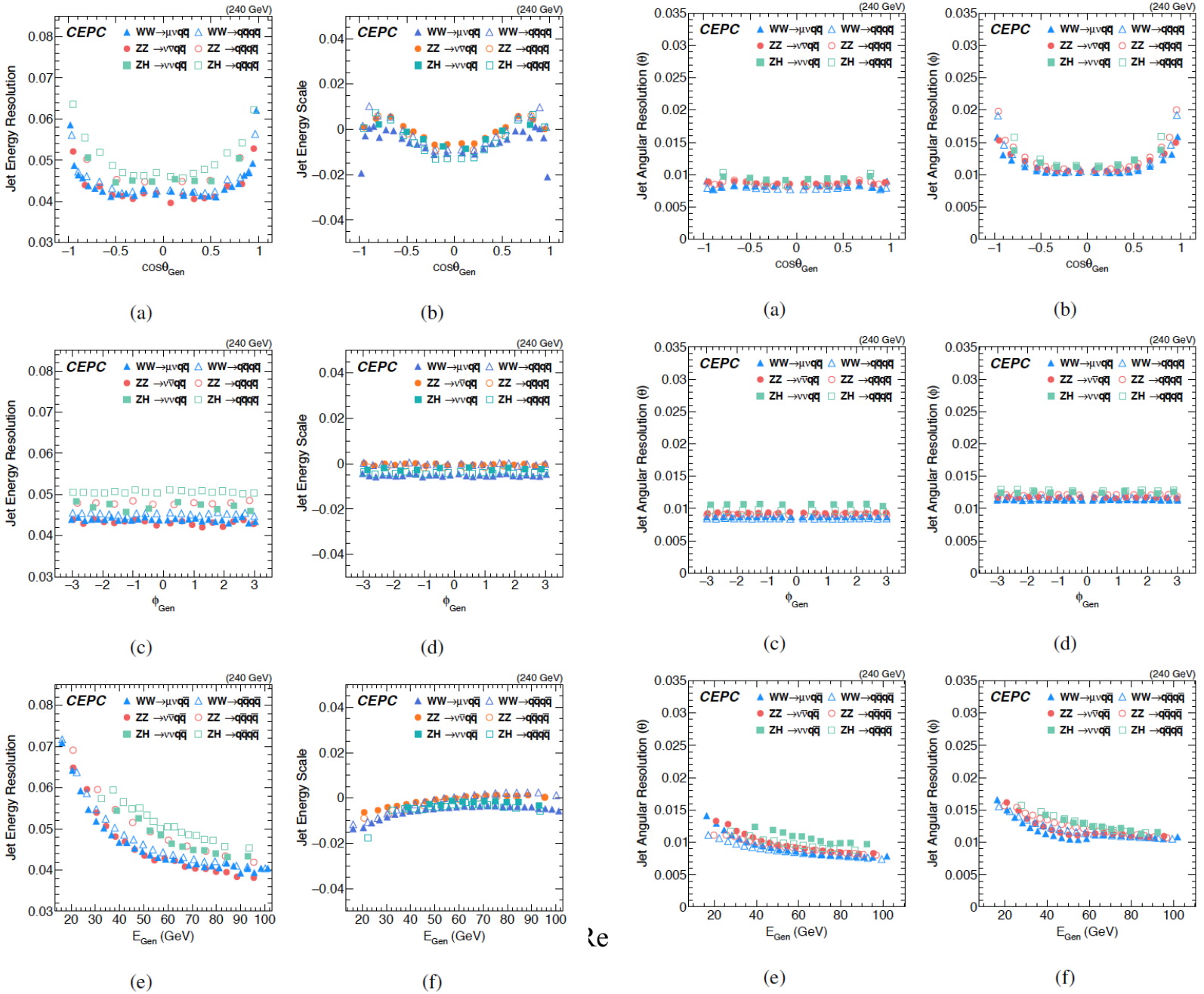




Peizhu

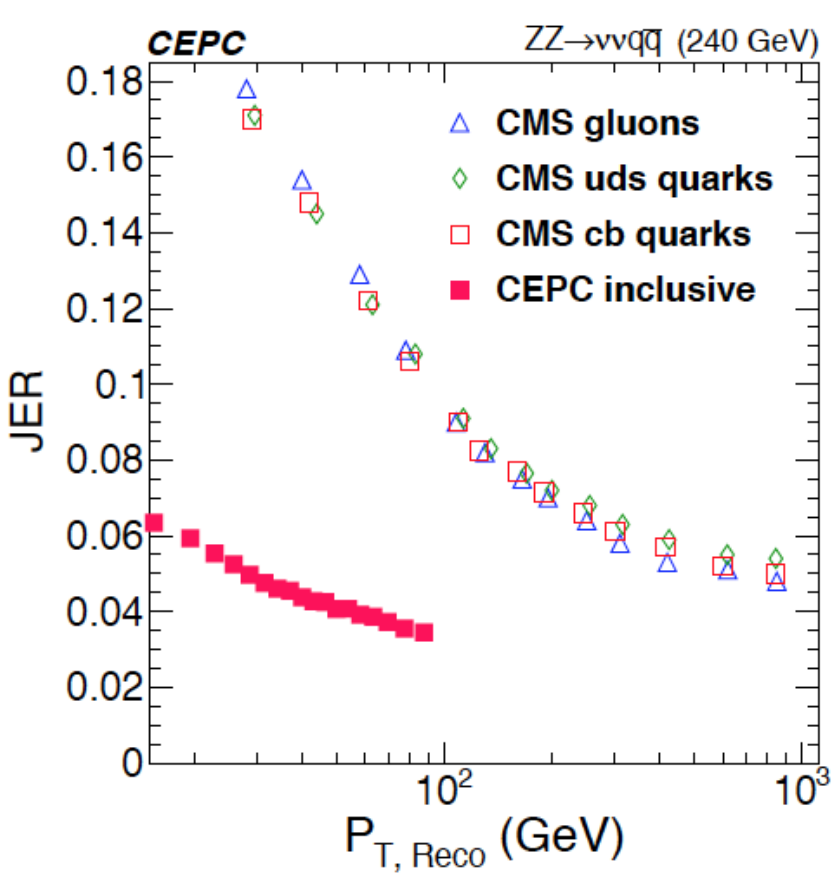
- Parton → Genjet → Recojet
- Matching between Genjet & Recojet using energy/direction information
- Relative difference between Gen/Recojet: Jet Energy Resolution/Scale, Jet Angular Resolution/Scale

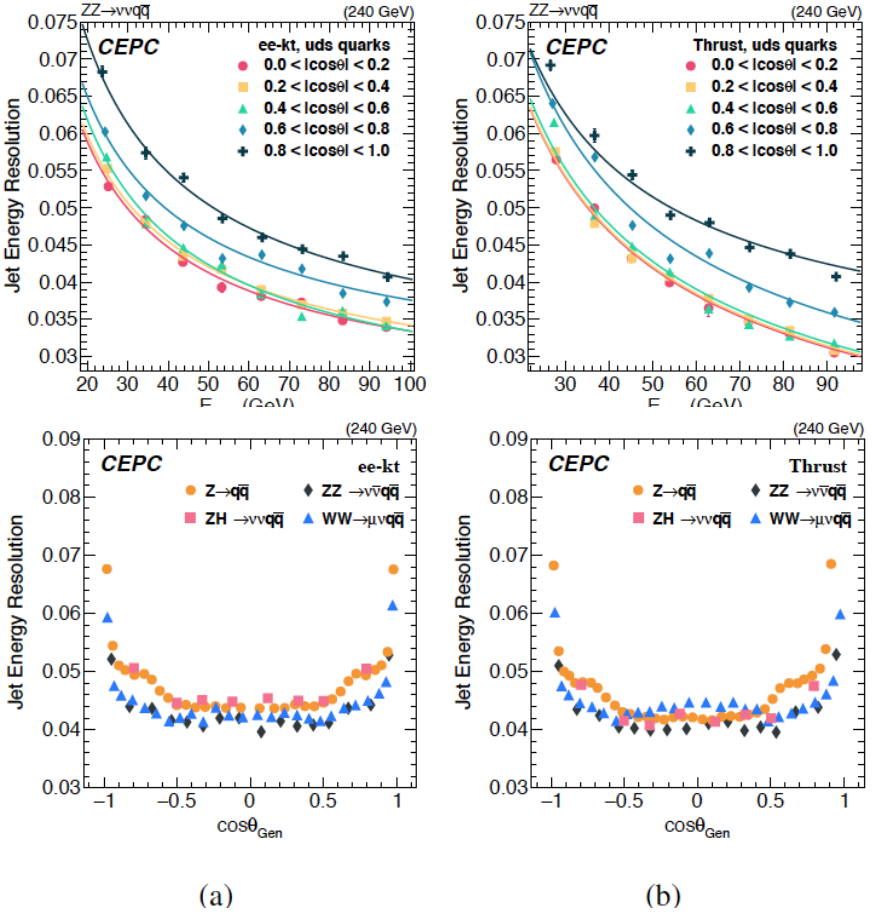
Differential response



Angular Scale: 1E-4!

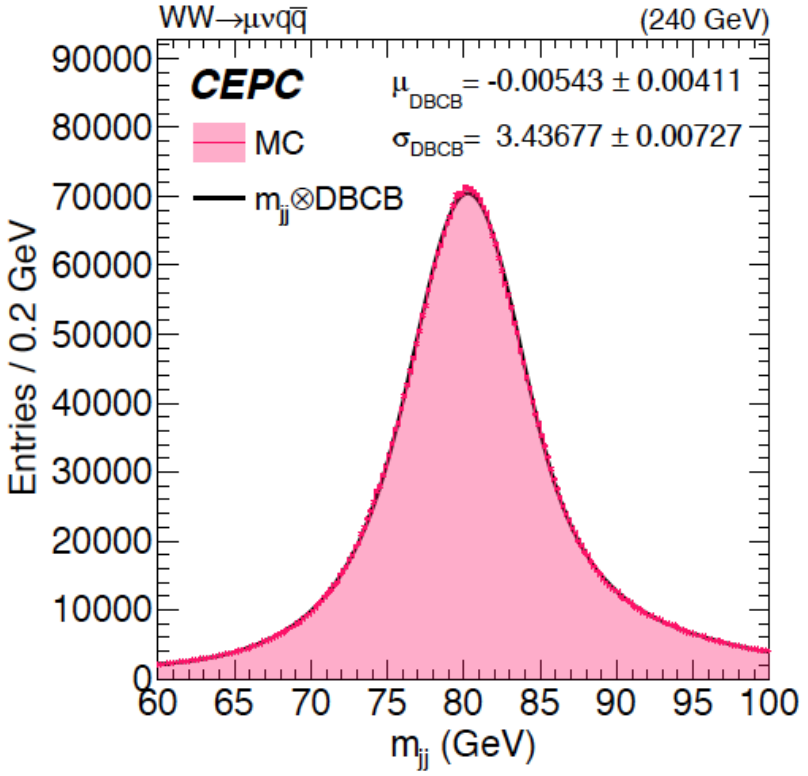
JER: much better than LHC at same Pt





- Dependence on the Jet Clustering Algorithm: up to 10%!...
- *What's the optimal choice of Jet clustering/matching for a given measurement? Why?...*

A very challenge & interesting topic



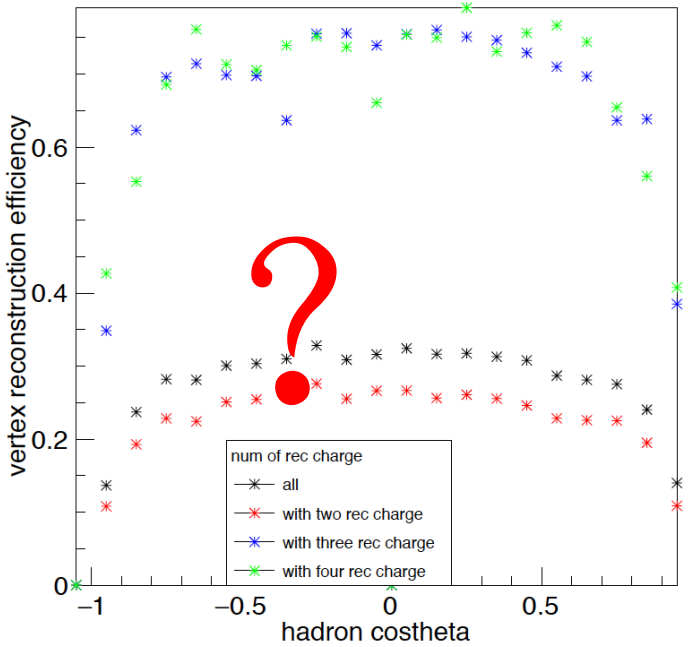
1E7 events

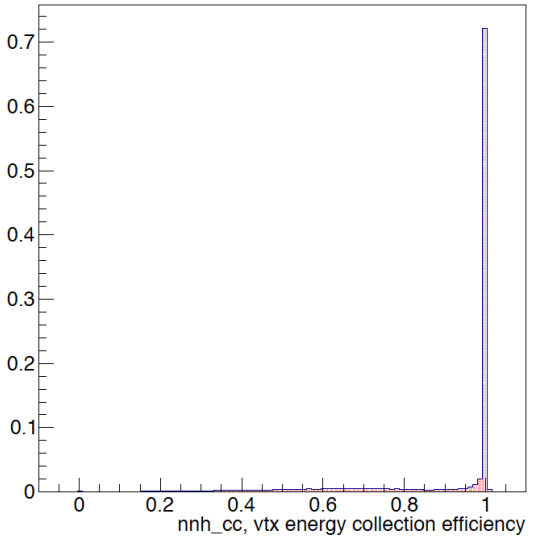
- W mass measurement at 240 GeV:
  - Statistic uncertainty ~ 1 MeV using only μνqq final state
  - Can we better control the systematic using the differential information & how to calibrate?

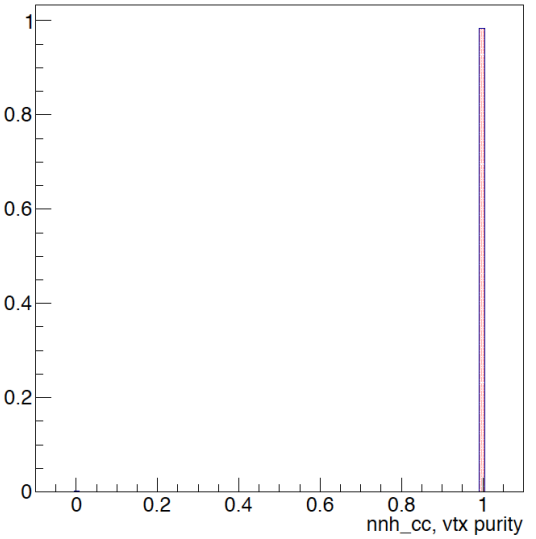
VTX reconstruction: Diagnosis

$$\frac{should\ \ been\ \ reconstructed\ \ vertex\ \ \&\&\ \ have\ \ been\ \ reconstructed\ \ vertex}{should\ \ been\ \ reconstructed\ \ vertex}$$

C-hadron with given charge multiplicity && corresponding tracks reconstructed



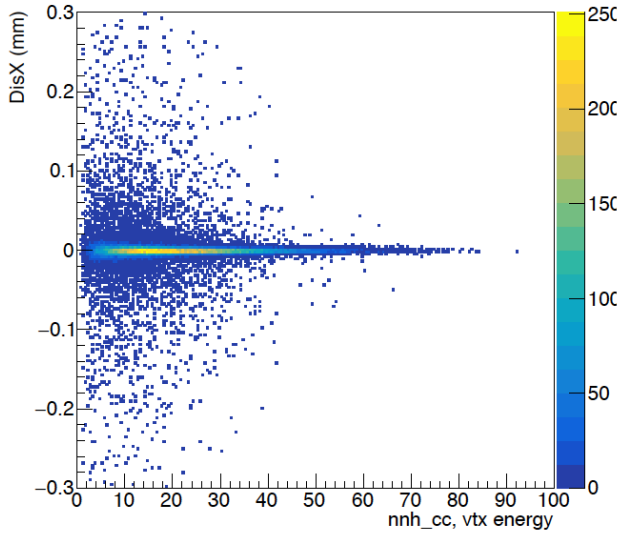


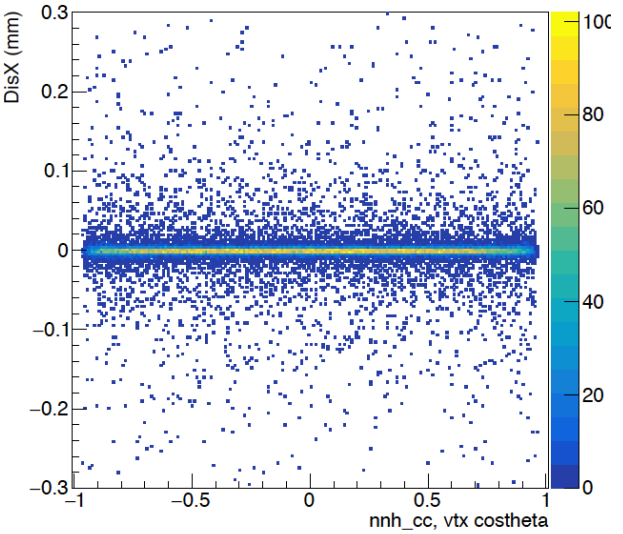


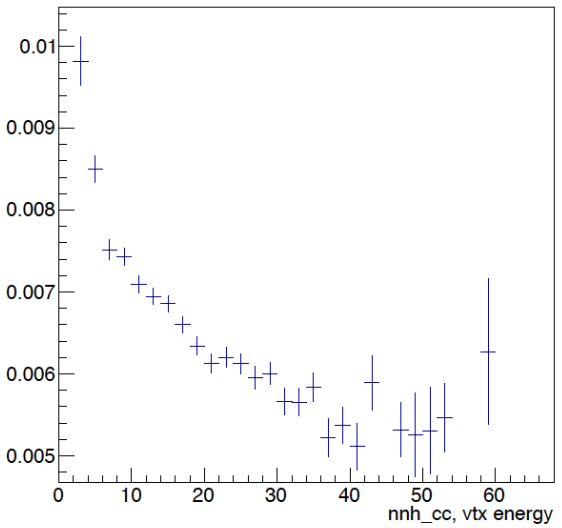
$$\frac{the\ \ vertex\ \ energy\ \ comes\ \ from\ \ hadron\ \ (RC)}{the\ \ energy\ \ of\ \ hadron\ \ charge\ \ particles\ \ (MC)} \qquad \frac{the\ \ vertex\ \ energy\ \ comes\ \ from\ \ hadron}{the\ \ energy\ \ of\ \ vertex}$$

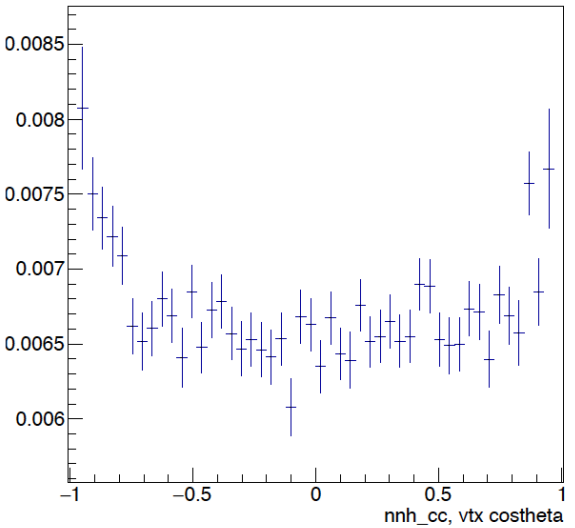
- At vvH, H→cc events.

VTX Position resolution (transverse): 5-10 μm









For more detail

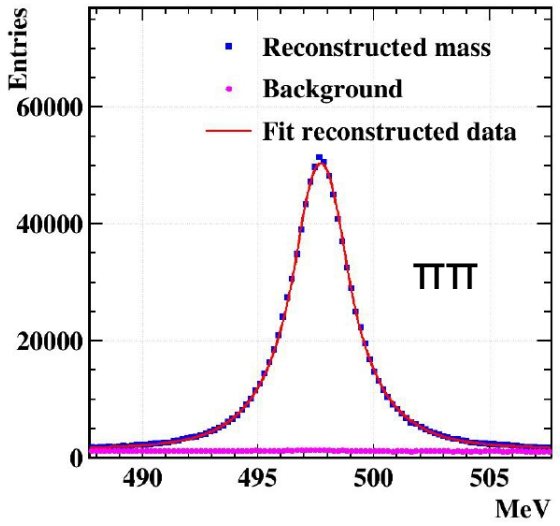
- Talks at Crystal Calorimeter WS https://indico.ihep.ac.cn/event/11938/other-view?view=standard
  - Jet lepton (Dan)
  - Differential jet response (Peizhu)
  - Optimization: BMR at different geometries (Yukun, Dan, Jiechen, Hanhua, etc)
  - Test of Principle: Reconstruction at crystal ECAL with bars in X/Y direction (Yuexin): 2 particle is solvable in super cell.

Summary

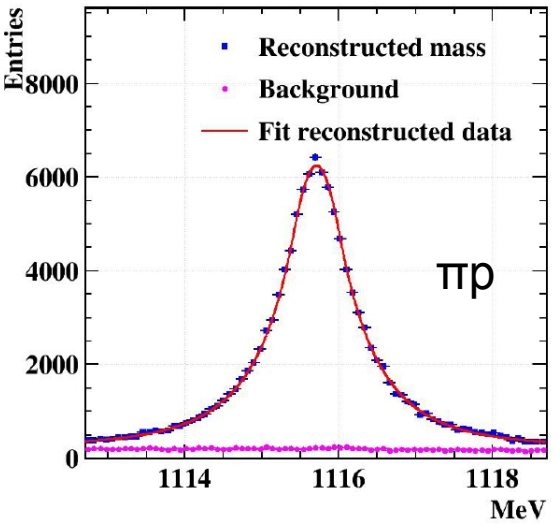
- Leptons:
  - Electron & Muon: Potential improvement is always possible, but not significant
    - Maximally ~10% improvement in total eff & purity for electron in b-jet
  - Tau: reasonable performance – improvement might be significant (eff*purity→50%)
  - Warp into publication
- Hadronic System:
  - BMR, standard & guidance the optimization:
    - BMR→3.6%. Allowance of 4% means cost can be significantly reduced w.r.t baseline.
    - Better BMR is an important: goal for Reco-Algorithm development.
  - Differential: Promising - Superb to LHC experiments (2-4 times in JER, 4-10 times in JES...) benchmark analyses, i.e., TGC is needed to fully understand the requirement
  - Need to be innovative, on differential measurements & Color Singlet identification
- VTX: at H→cc event
  - Looks good except **VERY LOW** efficiency for VTX with Charge Multiplicity of 2: **Diagnosis!**
  - Typical position resolution of 5-10 μm: need to understand
    - Is it good enough?
    - Relation with Tracker/VTX geometry?

Backup

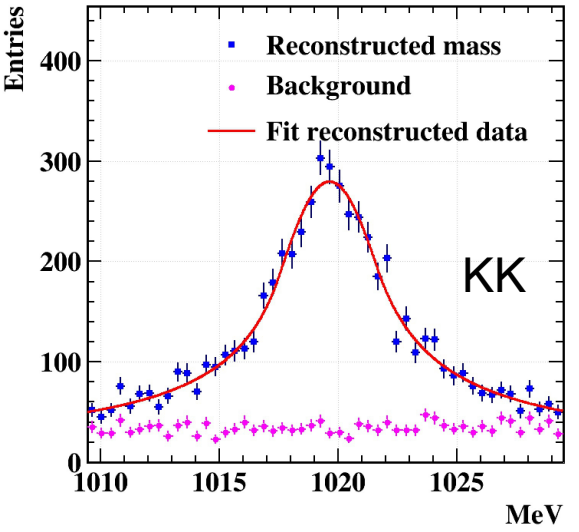
K_s, Λ, ϕ...

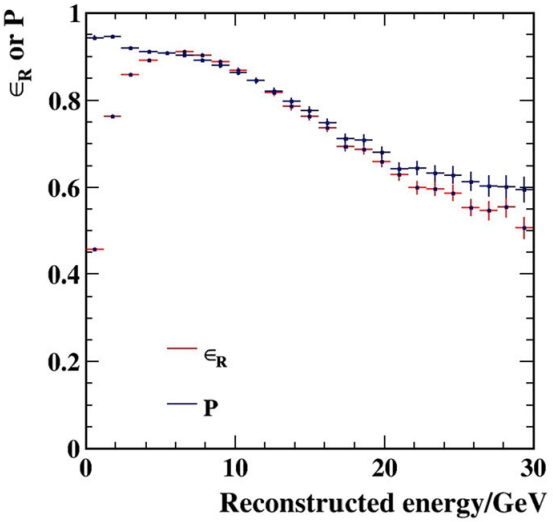


(a) K_S^0



(b) Λ





(a) K_S^0

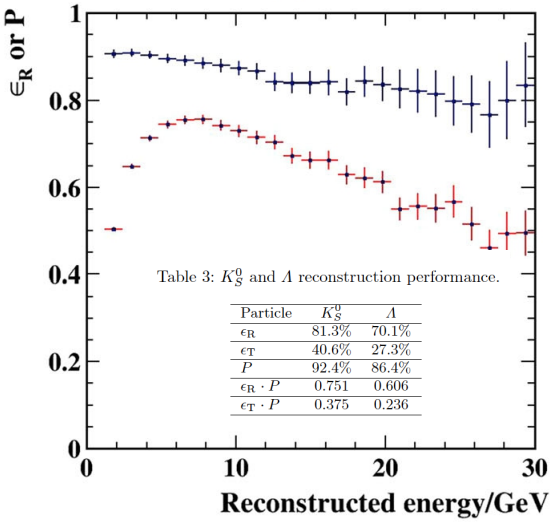
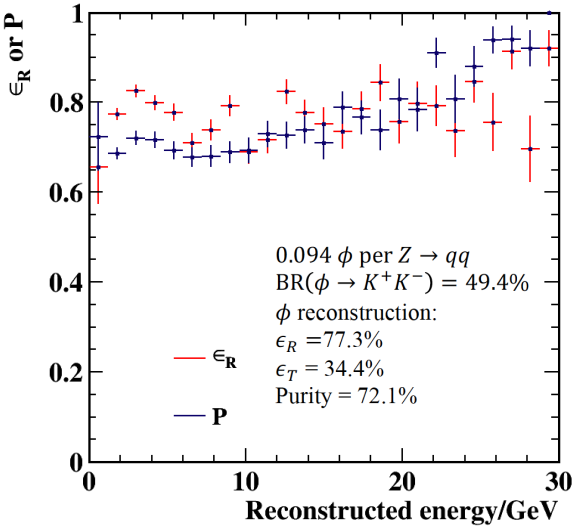


Table 3: K_S^0 and Λ reconstruction performance.

Particle	K_S^0	Λ
ϵ_R	81.3%	70.1%
ϵ_T	40.6%	27.3%
P	92.4%	86.4%
$\epsilon_R \cdot P$	0.751	0.606
$\epsilon_T \cdot P$	0.375	0.236

(b) Λ



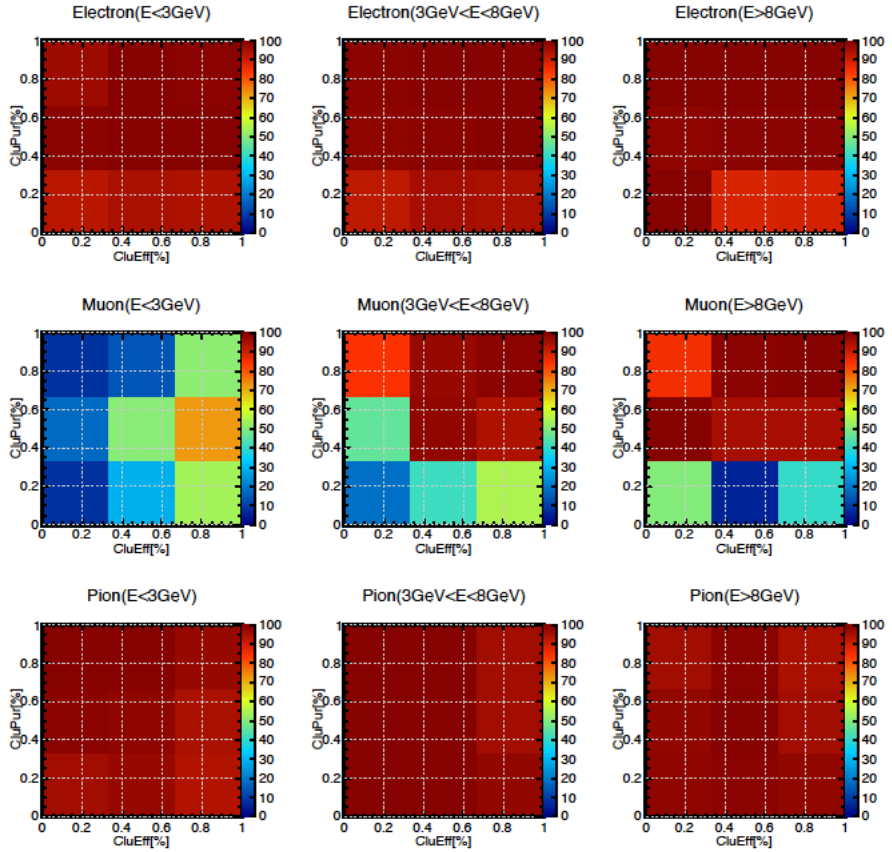


Fig. 8 The lepton identification efficiency in jets depending on clustering efficiency and purity.

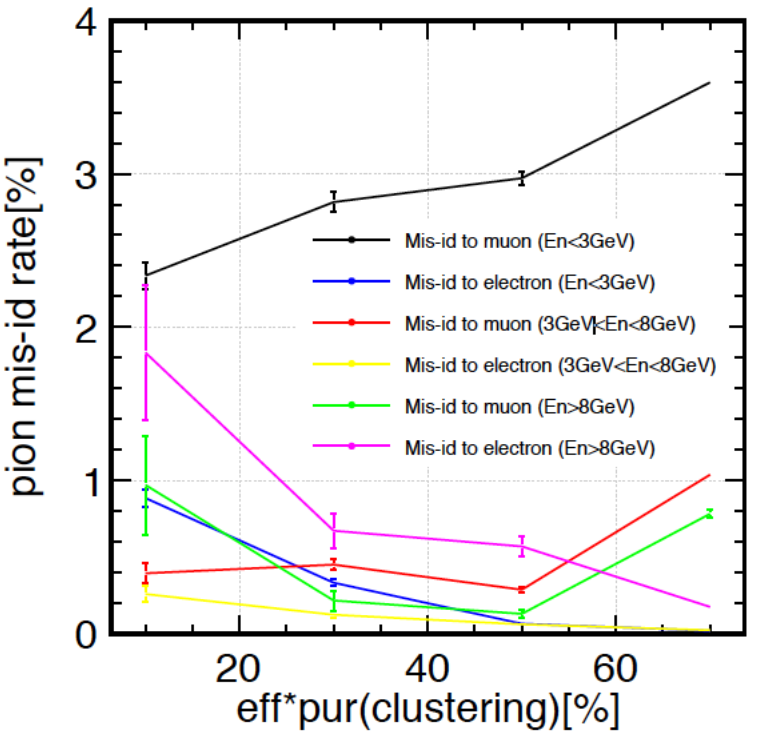


Fig. 9 The mis-id rate of pions to electrons or muons in jets, depending on clustering efficiency times purity.